

Aircraft Ice Protection

presented by Andy Reehorst

Nov. 13, 2000

Glenn Research Center

624101

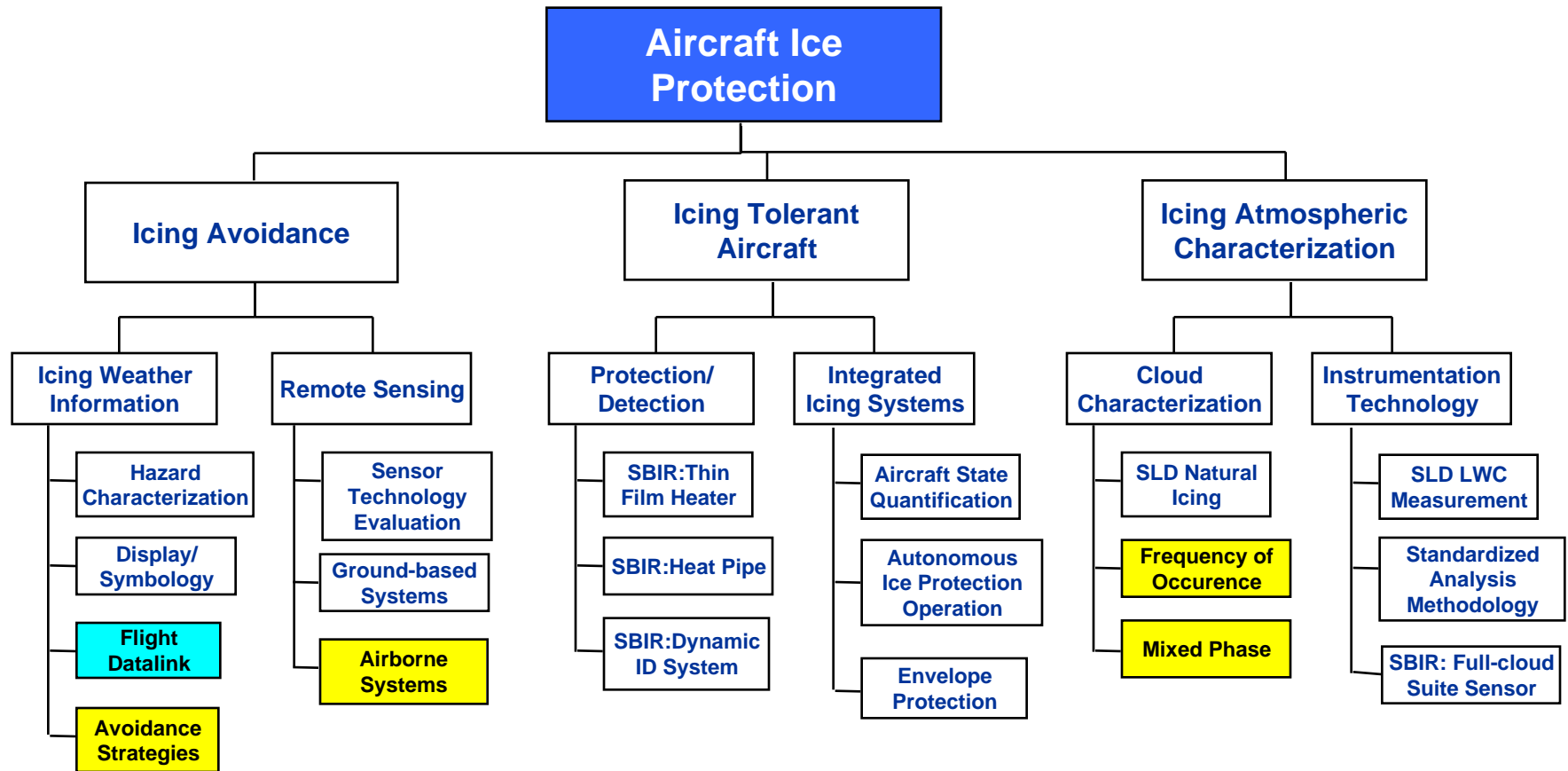
Icing Branch

Page 1

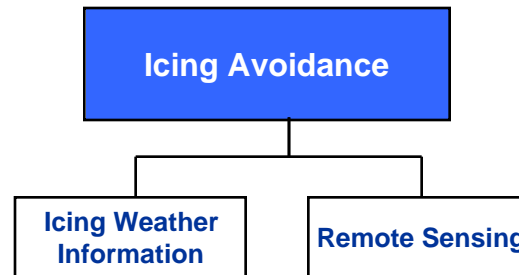
at Lewis Field



- Current Activities
- Planned Development
- Needed, Not Planned



Aircraft Ice Protection - Icing Avoidance



- ***Goal***

Provide flight crews with icing weather conditions information for avoidance or exit options

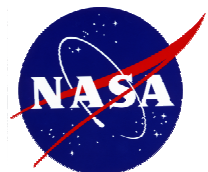
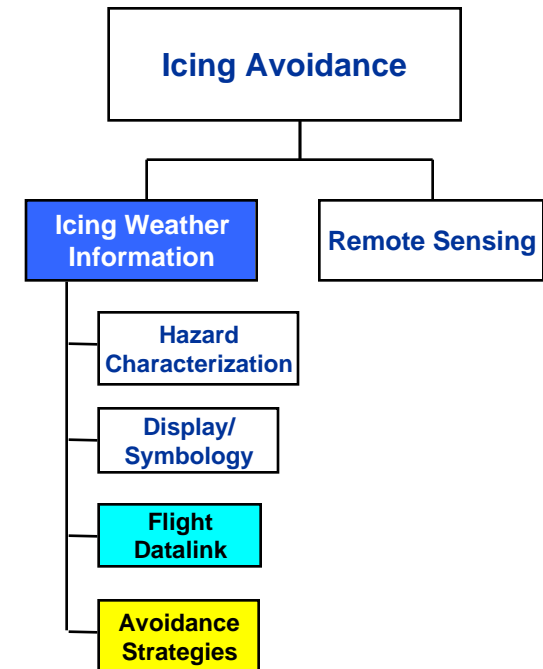
- ***Approach***

Develop technologies for the sensing and communication of the icing environment to provide the required information to flight crews, controllers, and dispatchers for improved decision making



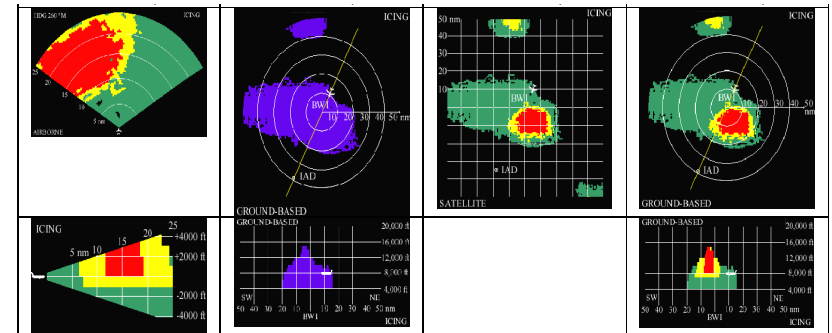
Icing Avoidance - Icing Weather Information

- Current Icing Weather Information tasks are focused on information gathered by remote sensing systems
- Includes need to characterize the environment and display the information to the flight crew in a manner that maximizes the impact of the information
- Planning to add an activity for FY01 for the datalinking of icing data for operational utilization

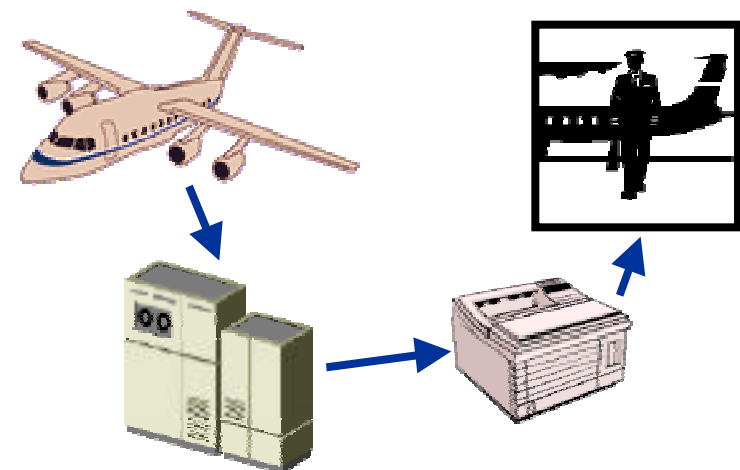


Icing Avoidance - Icing Weather Information

- Icing environment characterization and display/symbology issues being currently addressed for remote sensing by MIT under NASA grant
- MIT effort designed to maximize the operational value of remotely sensed icing environment information
- New activity planned to datalink ice detection data from aircraft to ground systems for weather product ingestion, then relay products to flight crews at gates



Icing Display Concepts from MIT



Icing datalink concept

Glenn Research Center

Icing Branch

Page 5

at Lewis Field



8/24/01

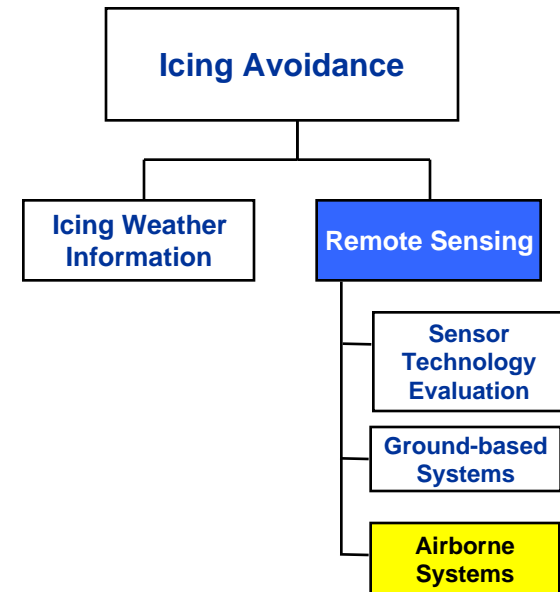
Icing Avoidance - Remote Sensing

- **Develop and field test remote sensing system technologies to reduce the exposure of aircraft to inflight icing hazards.**

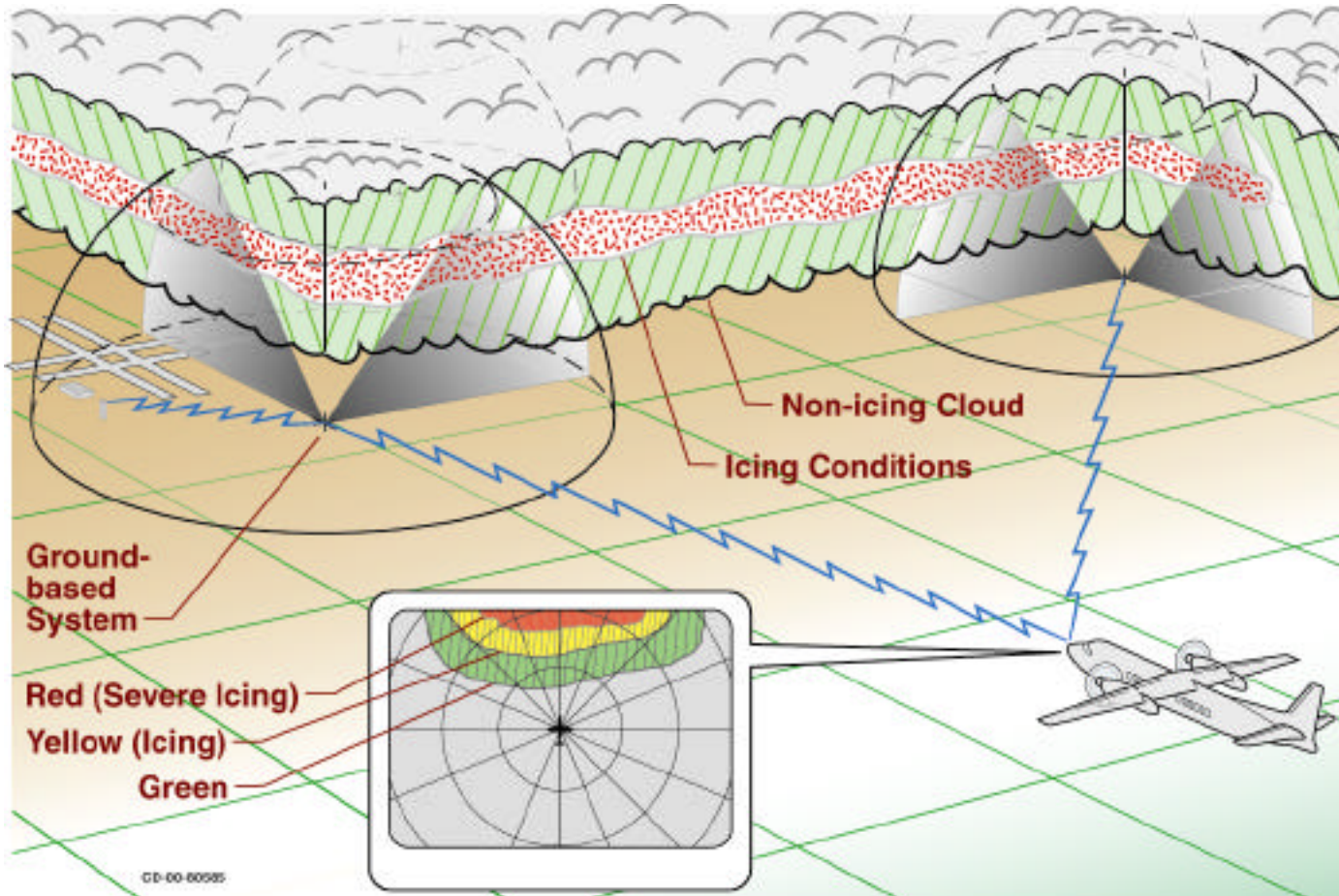
- The first technology form will be ground based and provide coverage in a limited terminal area to protect all vehicles.
- The second technology form will be airborne and provide unrestricted flight path coverage for a commuter class aircraft.

- **Note**

Utilizing a collaborative relationship with FAA AWR, NCAR, US Army CRREL, and MSC for the development of ground based icing remote sensing systems.



Ground Based System Concept

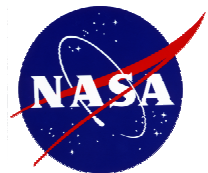


Glenn Research Center

Icing Branch

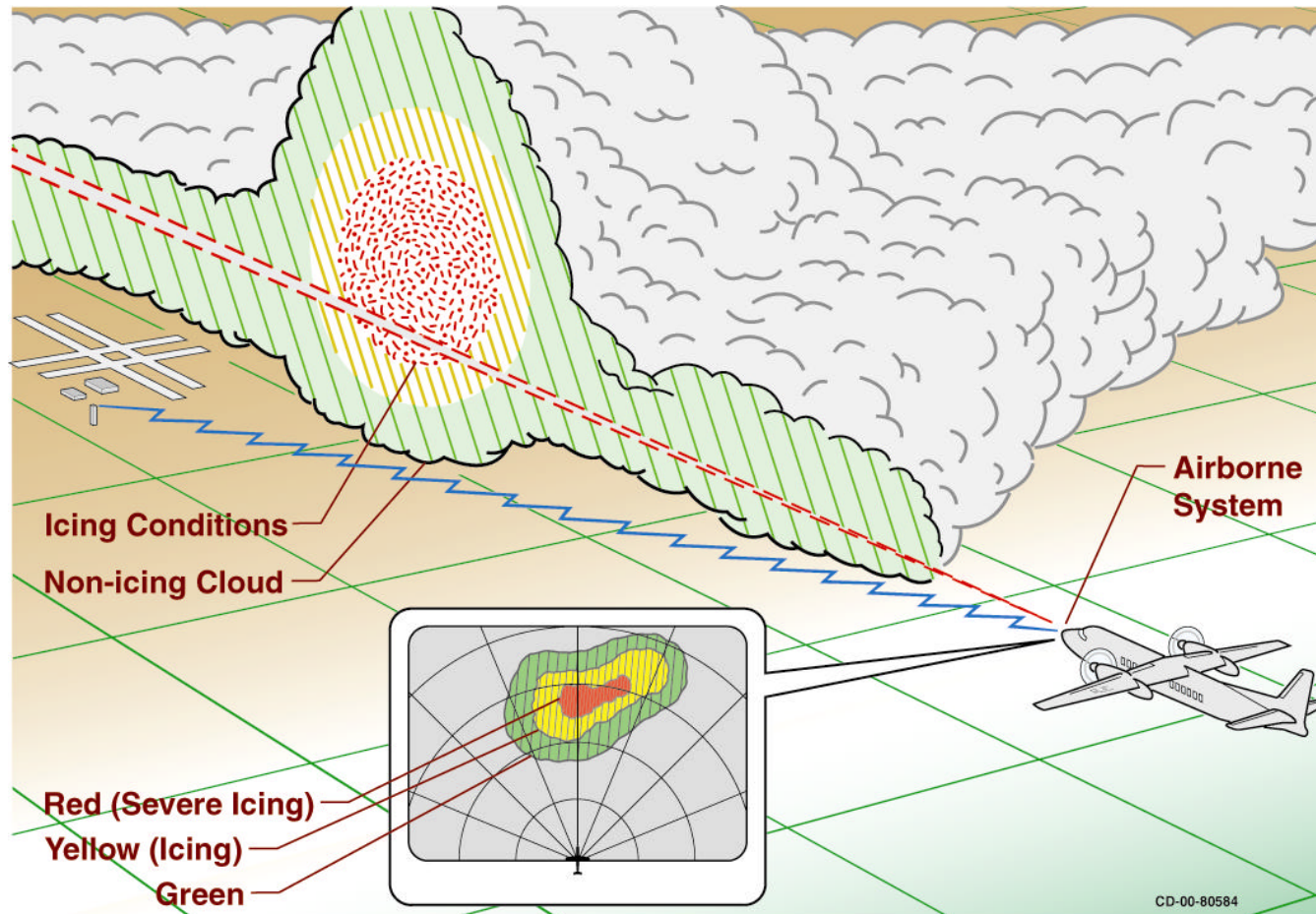
Page 7

at Lewis Field



8/24/01

Airborne System Concept



Glenn Research Center

Icing Branch

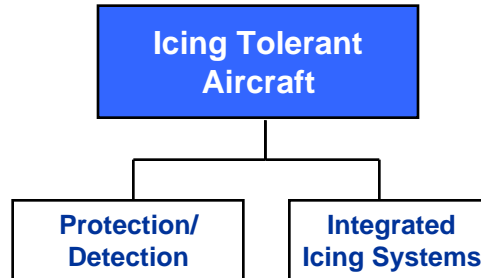
Page 8

at Lewis Field



8/24/01

Aircraft Ice Protection - Icing Tolerant Aircraft



- ***Goal***

Improve the ability of aircraft to operate safely in icing conditions

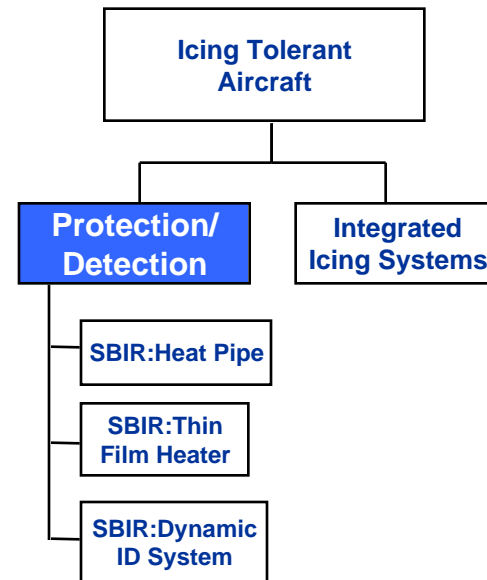
- ***Approach***

Develop technologies that will improve protection/ detection capability, identify the state-of-the-aircraft in the local icing environment, operate the ice protection equipment, and prevent uncontrolled aircraft responses to ice contamination



Icing Tolerant Aircraft - Protection/Detection

- Protection and Detection Development is accomplished by utilizing the NASA Small Business Innovative Research (SBIR) program
- Permits rapid funding of targets of opportunity
- Funding provided by SBIR program, not AOS
 - Leverages SBIR resources towards Project Office Goals in Aircraft Ice Protection elements



Glenn Research Center

Icing Branch

Page 10

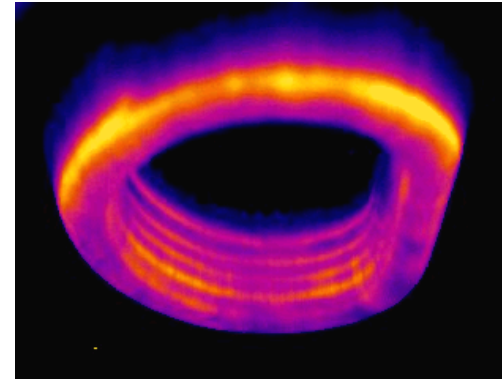
at Lewis Field



8/24/01

Icing Tolerant Aircraft - Protection/Detection

- Heat pipe technology developed by Thermacore, tested in the BFG tunnel with the Predator-B inlet
- Thin film heater technology developed by EGC, tested in the NASA IRT
- Aircraft dynamic response icing identification system developed by Systems Technology, Inc., to be tested on NASA Twin Otter this year



Thermal image of heatpipe ice protection



EGC thin film ice protection

Glenn Research Center

Icing Branch

Page 11

at Lewis Field



8/24/01

Icing Tolerant Aircraft - Integrated Icing Systems

- **Goal**

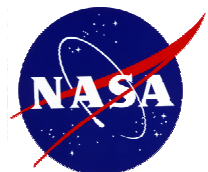
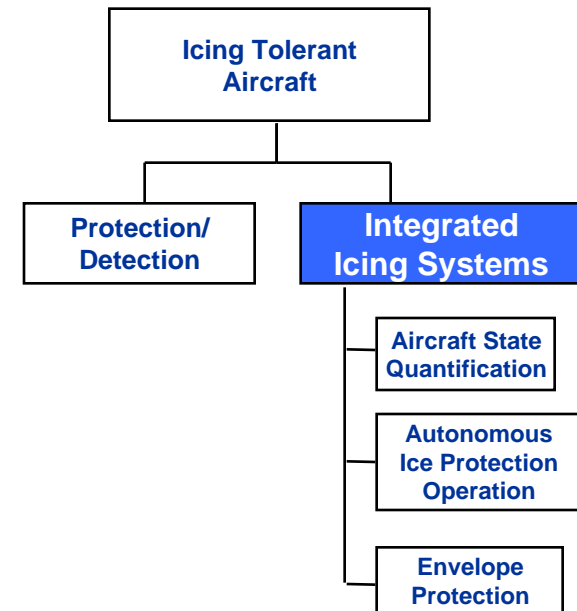
- To improve the safety of aircraft operating in icing conditions.

- **Objective**

- To develop a human-centered automated system, to characterize icing effects, operate the IPS, provide envelope protection and control adaptation.

- **Approach**

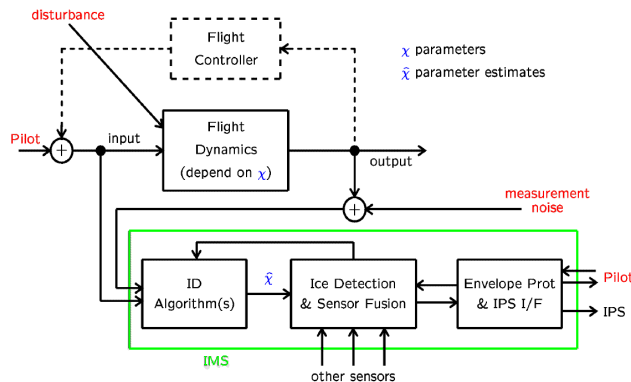
- An interdisciplinary, systems approach is used to conduct the research in aerodynamics, flight mechanics, controls and human factors. Flight simulation is used as a system integrator and flight test for development and evaluation.



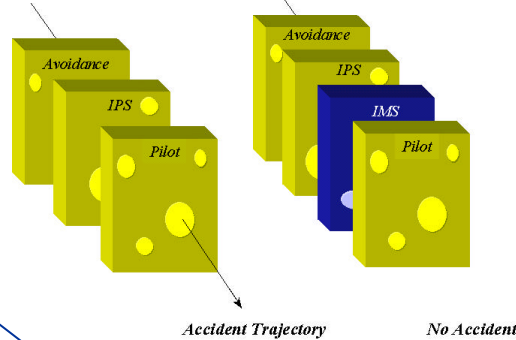
NASA/University of Illinois Smart Icing Systems Concept

Icing Characterization

Measure icing effects on performance and handling qualities in real time.



Layers of Icing Safety



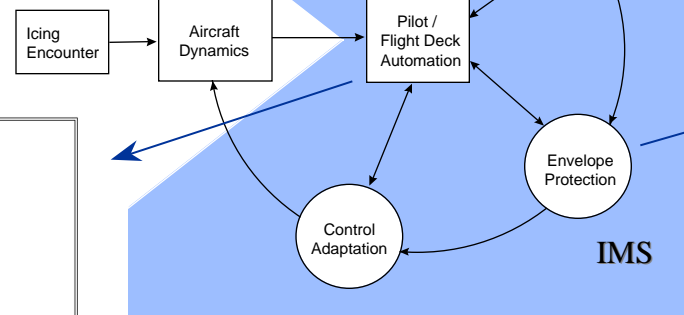
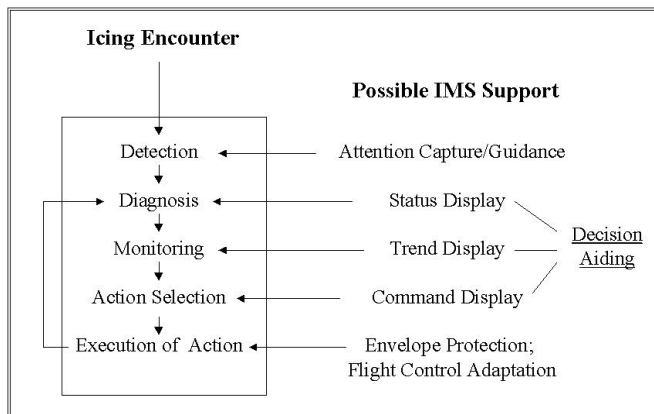
Autonomous IPS Operation

Activate IPS based on flight conditions, without requiring pilot input.



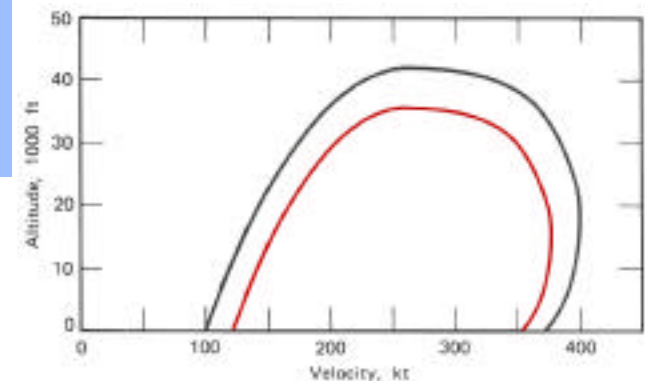
Human Factors

Human centered interfaces keep the pilot aware of IMS status and actions.



Envelope Protection

Use information for envelope protection and to reconfigure control laws.



Glenn Research Center

Icing Branch

Page 13

at Lewis Field

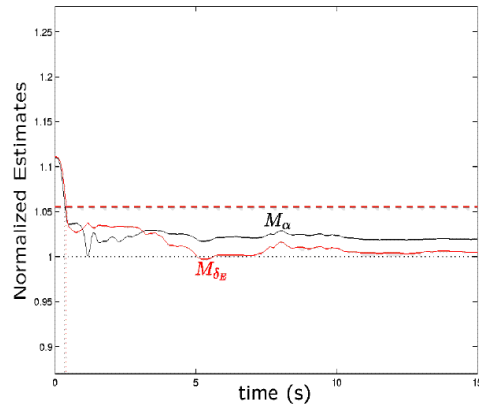


8/24/01

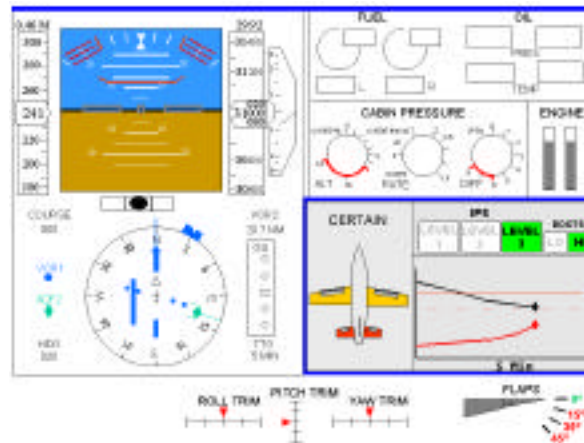
NASA/University of Illinois Smart Icing Systems Program

Technology Development

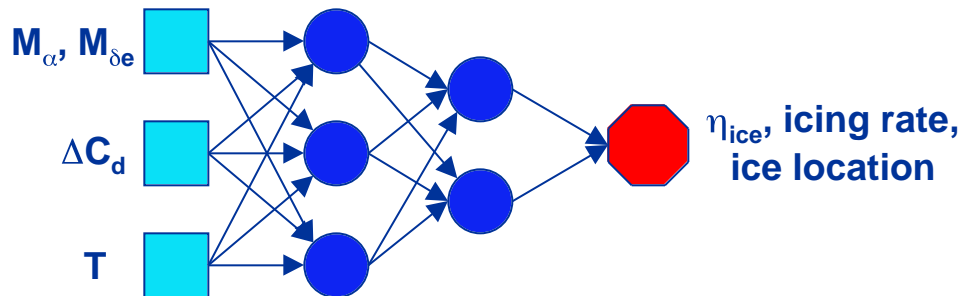
Systems Identification



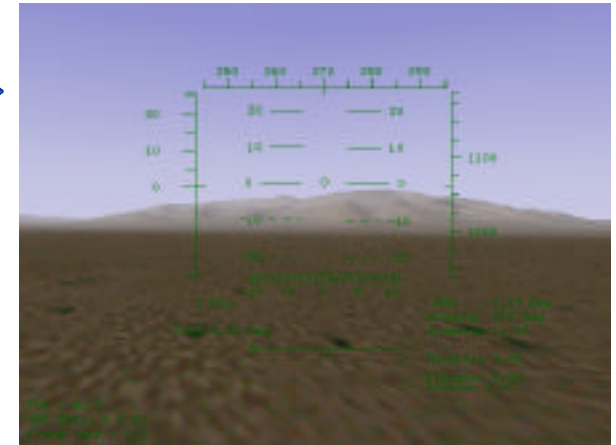
Human Factors



IMS Decision Making



Piloted Flight Simulator Systems Integration



Flight Test



Glenn Research Center

Icing Branch

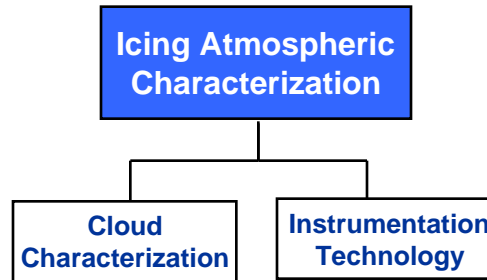
Page 14

at Lewis Field



8/24/01

Aircraft Ice Protection - Icing Atmospheric Characterization



- ***Goal***

Develop instrumentation and measurement techniques and characterize atmospheric icing conditions to improve simulation capability, provide icing weather validation databases, and increase knowledge of icing physics

- ***Approach***

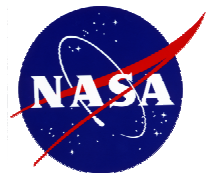
Conduct research flights in icing with flying laboratory and develop cloud physics instrumentation and analysis methods

Glenn Research Center

Icing Branch

Page 15

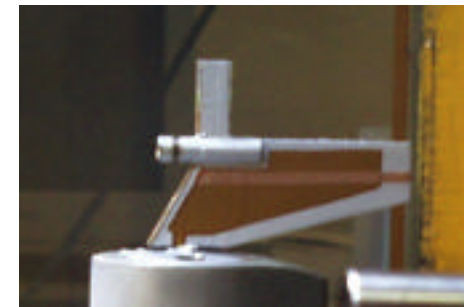
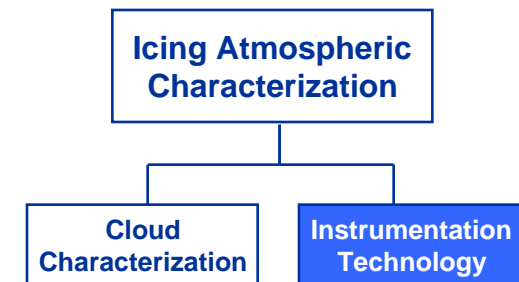
at Lewis Field



8/24/01

Icing Atmospheric Characterization - Instrumentation Technology

- Collaborating with Meteorological Service of Canada (MSC) to develop improved SLD cloud water content sensor
 - Existing cloud water instrumentation developed for Appendix C use
 - Conventional hot-wire cloud water content sensors read too low in SLD
- Conducted 2nd SLD instrumentation comparison test in September 2000
 - water droplet sizing & cloud water content
 - inter-compare probe responses to SLD
- Developed common SLD measurement & analysis methods with MSC
 - used by atmospheric research organizations (NCAR, CRREL)
 - allows for inter-comparison of different atmospheric datasets
 - standardization of methods needed within cloud physics organizations



SLD cloud water content sensor: captures large drops more efficiently, measures SLD cloud water content more accurately

Glenn Research Center

Icing Branch

Page 16

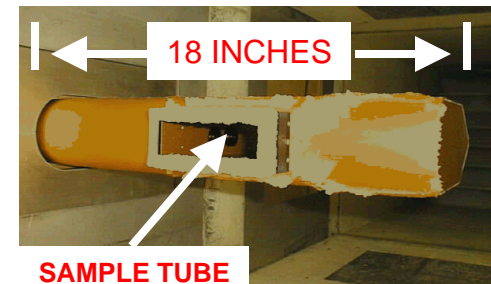
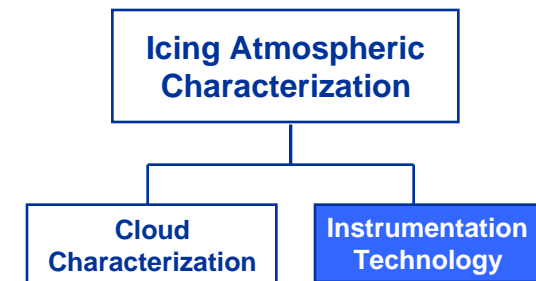
at Lewis Field



8/24/01

Icing Atmospheric Characterization - Instrumentation Technology

- Sponsoring development of compact airborne icing measurement system
 - full-suite of particle sizing instruments
 - cloud liquid & total water content
 - ice detector
 - airspeed / temperature
 - autonomous data acquisition system
- Develop with NASA SBIR funding
- Plan to demonstrate feasibility & use on commercial aircraft
 - eventual goal = installation on revenue service aircraft
 - obtain “random” measurements
 - use data to develop frequency of occurrence & global map of hazardous icing conditions



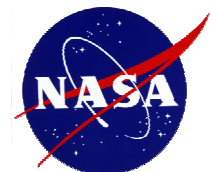
Complete icing cloud measurement system with data acquisition system; (*shown horizontally mounted*)

Glenn Research Center

Icing Branch

Page 17

at Lewis Field



8/24/01

SLD Flight & Instrumentation Comparison Tests

- Cooperative activities with MSC
- Improved SLD cloud data analysis methods
- Developed a standardized analysis method for use by entire atmospheric science community
- Delivered SLD cloud characterization database to FAA
- Collaborated with NCAR to improve flight test SLD forecast capability and provide validation dataset for forecast tool development
- Completed instrumentation test in IRT with US and international probe developers.
 - Allowed the comparison of probes in controlled environment
 - Assessed latest improved instrumentation



Instrumentation on Twin Otter



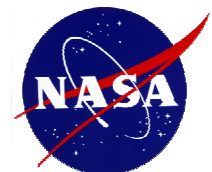
Cloud Instrumentation test in IRT

Glenn Research Center

Icing Branch

Page 18

at Lewis Field



8/24/01